

## ***Appendix E – Evaluation of Potential Propellants***

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## APPENDIX E

### EVALUATION OF POTENTIAL PROPELLANTS THAT MAY BE USED BY THE SLLP PROJECT DURING THE PERIOD OF THE LAUNCH OPERATOR LICENSE

As discussed in Section 2.2, during the span of operations considered under the launch operator license (i.e., five years), alternative propellants may be employed on the Upper Stage. Two identified alternatives are Unsymmetrical Dimethylhydrazine (UDMH, or formally 1,1-Dimethylhydrazine) and Boktan (a Russian produced kerosene substitute). Operational evaluations of these products specific to the SLLP project have not been conducted to date. General information, however, is available and has been collected to conduct a preliminary analysis of the environmental consequences of the use of these propellants.

#### *E.1 UDMH*

The use of Monomethylhydrazine (MMH) in conjunction with  $N_2O_4$  was evaluated in the February 11, 1999, EA and is used as a reference for comparison here. A potential alternative propellant is Unsymmetrical Dimethylhydrazine (UDMH, or formally 1,1-Dimethylhydrazine) both U.S. Grade and Russian Grade. The quantities of UDMH potentially used in the Upper Stage would be the same as the quantity of MMH currently used in the Upper Stage (approximately 25 to 50 liters, or 7 to 13 gallons).

##### **E.1.1 Comparison of Chemical/Physical and Safety Parameters and Preliminary Analysis**

Table E-1 presents several important chemical and physical and safety parameters for UDMH and MMH. A preliminary analysis of the environmental impacts of the use of UDMH, compared with MMH, follows.

**Table E-1: Summary of Chemical/Physical and Safety Parameters for UDMH (U.S. and Russian Grade) and MMH**

	UDMH	UDMH (Russian Grade)	MMH
<b>General Information:</b>			
Name	1,1-Dimethylhydrazine	1,1-Dimethylhydrazine	Monomethylhydrazine
Chemical formula	$(\text{CH}_3)_2\text{NNH}_2$	$(\text{CH}_3)_2\text{NNH}_2$	$\text{CH}_3\text{NHNH}_2$
Molecular weight	60.10	60.10	46.07
CAS:	57-14-7	not listed	60-34-4
Composition—	1,1-dimethylhydrazine: 95-99% dimethyl amine: 1-5% water: 0.1 to 1%	1,1-dimethylhydrazine: 98.6% dimethyl amine: 0.5% methyl alcohol: 0.4% water: 0.5%	methylhydrazine: 95-99% water: 1 to 5%
<b>Chemical/Physical Characteristics:</b>			
Boiling point	63°C	63°C	87.5°C
Melting Point	-58°C	-57°C	-52.4°C
Vapor Pressure	157 mm Hg (at 25°C)	not available	49.6 mm Hg (at 25°C)
Vapor Density (air = 1)	2.07	not available	1.59
Specific Gravity	0.80 (at 20°C)	0.790 (at 20°C)	0.874 (at 25°C)
Flash point	-15°C (COC)	-18°C (Abel)	21°C (COC method)
Solubility in Water	miscible	soluble	miscible
Appearance--	clear, colorless liquid with ammonia odor	colorless or light yellow fuming in the air high-toxic liquid with ammonia odor	clear, colorless liquid with amine odor
<b>Handling &amp; Safety Information:</b>			
Reactivity	stable, avoid: heat, sparks, open flame, strong oxidizers	explosive, highly inflammable liquid; easily oxidizes	stable, avoid: temperatures greater than 88°C, static discharge, direct sunlight, heat, sparks strong oxidizers
Decomposition/Combustion products	carbon monoxide, nitrogen oxides	soot, carbon monoxide, nitrogen oxides	carbon monoxide, nitrogen oxides
Hazard classification	classified as IB flammable liquid, corrosive	classified as extremely dangerous substances, Class 1 of danger by effect on organism <sup>a/</sup> (GOST 12.1.007-76)	classified as IB flammable liquid
<b>Health Hazard Data:</b>			
Exposure limits and effects	OSHA PEL: 1mg/m <sup>3</sup> (skin) Oral LD <sub>50</sub> (rat) 122 mg/kg; not considered carcinogenic	Toxicity level (max. permissible) 0.1mg/m <sup>3</sup> in production rooms air; 0.001mg/m <sup>3</sup> in atmospheric air—maximum single and daily average	OSHA PEL: 0.35mg/m <sup>3</sup> (skin) Oral LD <sub>50</sub> (rat) 32 mg/kg; considered mutagenic but not carcinogenic

NOTE: <sup>a/</sup> Class 1 GOST is the most dangerous.

#### Sources:

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Unsymmetrical Dimethyl Hydrazine*, Nov. 10, 2000.  
NIOSH, *Pocket Guide to Chemical Hazards: Methyl hydrazine*, [www.cdc.gov/niosh/npg/npgd0419.html](http://www.cdc.gov/niosh/npg/npgd0419.html) as of Dec. 18, 2000.  
NIOSH, *Pocket Guide to Chemical Hazards: 1-1 Dimethylhydrazine*, [www.cdc.gov/niosh/npg/npgd0227.html](http://www.cdc.gov/niosh/npg/npgd0227.html) as of Dec. 18, 2000.  
NIOSH, *Manual of Analytical Methods (NMAM): 1-1 Dimethylhydrazine, Method 3515*, Fourth Edition, Aug. 15, 1994.  
NIOSH, *Manual of Analytical Methods (NMAM): Monomethylhydrazine, Method 3510*, Fourth Edition, Aug. 15, 1994.  
Olin Corporation, *Material Safety Data Sheet: Unsymmetrical dimethylhydrazine*, <http://msds.pdc.cornell.edu/msds/siri/msds/h/q197/q293.html>, Dec. 18, 2000.  
Olin Corporation, *Material Safety Data Sheet: Monomethylhydrazine*, <http://msds.pdc.cornell.edu/msds/siri/msds/h/q384/q195.html>, Dec. 18, 2000.

UDMH and MMH are both hydrazines with several differences in chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, flash point). The two fuels, however, are similar in terms of reactivity, products of combustion (based on  $\text{N}_2\text{O}_4$  as an oxidizer), exposure limits, and hazard classification. Consequently, the handling of these fuels at Home Port and on board the Launch Platform would be equivalent to procedures undertaken for previous missions, although containers and labeling requirements may vary based on relevant regulatory requirements. Equally important, the combustion emissions of the two fuels will be similar (there will be a variation in the stoichiometric ratios—i.e., the quantitative relationship between substances in processes involving chemical change) and will occur at the same altitudes as described in the February 11, 1999 EA.

#### E.1.2 Effect on Home Port & Marine Operations

The change from MMH to UDMH does not have a large impact on Home Port permitting. The following documents need to be amended prior to UDMH arrival on-site:

- a) Hazardous Material Inventory (EPCRA), Long Beach Department of Health (CUPA)
- b) Business Emergency Plan, Long Beach Fire Department
- c) Operations Manual for the Transfer of Hazardous Material in Bulk, USCG
- d) Integrated Contingency Plan

The following document will need to reflect the change in 2002:

- e) Annual Emissions Inventory (Year 2001), SCAQMD

The following document will not require changes because thresholds are not exceeded:

- f) Risk Management Plan, Long Beach Department of Health (CUPA)

Regarding the physical changes to Home Port or ship-board operations, Kvaerner Govan's HVAC contractor, Novenco, had specific scrubber filter elements designed, constructed, and delivered that would capture and properly neutralize vapors from UDMH. Following approval of the use of UDMH, these scrubbers will be installed at the SLLP facilities.

#### E.2 BOKTAN

The use of kerosene (Russian grade) in conjunction with LOX was evaluated in the February 11, 1999, EA and is used as a reference for comparison here. A potential alternative propellant is Boktan, a Russian produced kerosene substitute classified as a hydrocarbon product composed mainly of cycloalkanes. The quantities of Boktan potentially used in the Upper Stage would be approximately the same as the quantity of kerosene currently used in the Upper Stage (4,325 kg. or 9,515 lbs.).

### **E.2.1 Comparison of Chemical/Physical and Safety Parameters and Preliminary Analysis**

Table E-2 presents several important chemical and physical and safety parameters for Boktan and kerosene. A preliminary analysis of the environmental impacts of the use of Boktan, compared with kerosene, follows.

**Table E-2: Summary of Chemical/Physical and Safety Parameters for Kerosene (U.S. and Russian Grade) and Boktan**

	<b>Boktan</b>	<b>Kerosene</b>	<b>Kerosene (Russian Grade)</b>
<b><i>General Information:</i></b>			
Chemical class	cycloalkanes	hydrocarbon fraction	hydrocarbon fraction
Common name	boktan (or naphthenes)	kerosene	naphthyl
Elemental composition	CH <sub>2</sub>	CH <sub>1.96</sub> (average)	no information
Composition—	“boktan” or cycloalkanes – 98% dicyclobutylidene – 0.5% light impurities – 1.3% heavy impurities – 0.2% water – 0.05%	complex mixture of hydrocarbons blended to meet product specifications; composition varies and includes C9 to C16 hydrocarbons; common components include hydrodesulfurized kerosene, hydrotreated distillate light, straight run kerosene; functional and performance additives may also be present	mixture of petroleum fractions with boiling point ranges; 98% is distilled at a temperature not higher than 270°C  aromatic hydrocarbons 5.0% sulfur 0.01% 4-methyl 2,6 ditertiary butylphenol 0.005 to 0.006% resins 2,0 % dissolved water 0.0006%
<b><i>Chemical/Physical Characteristics:</i></b>			
Boiling point	134°C	151°C to 301°C	no information
Melting Point	-62.7°C to -54.5°C	-18°C	no information
Vapor Pressure	no information	0.5 m Hg at 20°C	0.3 mm Hg at 17°C
Vapor Density (air = 1)	no information	4.5	no information
Specific Gravity	0.829	0.80 to 0.81	0.833
Flash point	19°C	38°C PM minimum	61°C
Solubility in Water	no information	insoluble	insoluble
Appearance	colorless clear liquid	colorless to pale straw, or red oily liquid with characteristic odor	colorless transparent liquid with a specific odor of gasoline
<b><i>Handling &amp; Safety Information:</i></b>			
Reactivity	highly stable; incompatible with oxidizers, explosives and inflammable substances	stable under normal conditions; incompatible with sources of ignition	inert liquid, explosion hazard
Decomposition/Combustion products	carbon oxides	carbon oxides	carbon oxides
Hazard classification	Class 3 of danger, <sup>a/</sup> moderately hazardous substances (per GOST 12.1.007-76)	DOT Hazard Class 3 or Combustible Liquid	Low toxic substance, Class 4 (per GOST 12.1.007-76)
<b><i>Health Hazard Data:</i></b>			
Exposure limits and effects	toxicity level: max. permissible concentration in production rooms = 5 mg/m <sup>3</sup>	NIOSH proposed limit of 100 mg/m <sup>3</sup> for 8 hr.; ACGIH proposed exposure limit of 100 mg/m <sup>3</sup>	maximum allowable concentrations of vapors in production rooms = 300 mg/m <sup>3</sup> , in populated areas = 5 mg/m <sup>3</sup> ; and in water 0.1mg/dm <sup>3</sup> .

NOTE: a/ Class 1 GOST is the most dangerous.

Sources:

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Boktan*, Sept. 9, 1999.

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Naphthyl*, Sept. 25, 1997

T.W. Brown Oil Co., Inc., *Material Safety Data Sheet for Kerosene*, [www.brownoil.com/msdskerosene.htm](http://www.brownoil.com/msdskerosene.htm), as of February 6, 2001.

The most significant difference between Boktan and kerosene is in chemical classification. Although both hydrocarbons, kerosene is a blend of mainly normal, straight-chain alkanes whereas Boktan is mainly a mixture of cycloalkanes. The ratio of carbon to hydrogen is roughly the same, however. Regarding material stability, both Boktan and kerosene are stable liquids incompatible with sources of ignition or explosion. Hazard classifications for Boktan and kerosene are comparable, although Boktan has a lower exposure limit in occupational settings. The combustion products of the two propellants will be similar (carbon dioxide and possibly carbon monoxide; and the stoichiometric ratios should be relatively similar). Furthermore, emissions would occur at the same altitudes as described in the February 11, 1999, EA.

### **E.2.2 Effect on Home Port & Marine Operations**

It is assumed that Boktan would be handled in the same manner as kerosene is currently handled—i.e., it would not be stored on Home Port property. The Integrated Contingency Plan would have to be updated with a name change (Boktan for kerosene), and any associated Emergency Procedures that may differ than for kerosene would have to be reviewed and documented. Regarding the Operations Manual for the Transfer of Hazardous Materials in Bulk, a name change and any associated emergency procedures that may be different would need to be recorded. Also, Boktan would need to be added to the Annual Emissions Inventory. Finally, Boktan may need to be included in the Risk Management Plan. This may be considered only an update, however, as kerosene has been classified as fuel and Boktan may remain within the same classification.

***Appendix F – IUCN and WCMC Listing Status  
Categories***

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## APPENDIX F

### IUCN AND WCMC LISTING STATUS CATEGORIES

**EXTINCT (EX)** - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

**EXTINCT IN THE WILD (EW)** - A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

**CRITICALLY ENDANGERED (CR)** - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below.

**ENDANGERED (EN)** - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.

**VULNERABLE (VU)** - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described below.

**LOWER RISK (LR)** - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (cd).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

**DATA DEFICIENT (DD)** A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

**NOT EVALUATED (NE)** A taxon is Not Evaluated when it has not yet been assessed against the criteria.

## USFWS LISTING STATUS CATEGORIES

**E** -- Endangered  
**T** -- Threatened  
**EmE** -- Emergency Listing, Endangered  
**EmT** -- Emergency Listing Threatened  
**EXPE, XE** -- Experimental Population, Essential  
**EXPN, XN** -- Experimental Population, Non-Essential  
**SAE, E(S/A)** -- Similarity of Appearance to an Endangered Taxon  
**SAT, T(S/A)** -- Similarity of Appearance to a Threatened Taxon  
**PE** -- Proposed Endangered  
**PT** -- Proposed Threatened  
**PEXPE, PXE** -- Proposed Experimental Population, Essential  
**PEXP, PXN** -- Proposed Experimental Population, Non-Essential  
**PSAE, PE(S/A)** -- Proposed Similarity of Appearance to an Endangered Taxon  
**PSAT, PT(S/A)** -- Proposed Similarity of Appearance to a Threatened Taxon  
**C** -- Candidate Taxon, Ready for Proposal  
**D3A** -- Delisted Taxon, Evidently Extinct  
**D3B** -- Delisted Taxon, Invalid Name in Current Scientific Opinion  
**D3C** -- Delisted Taxon, Recovered  
**DA** -- Delisted Taxon, Amendment of the Act  
**DM** -- Delisted Taxon, Recovered, Being Monitored First Five Years  
**DO** -- Delisted Taxon, Original Commercial Data Erroneous  
**DP** -- Delisted Taxon, Discovered Previously Unknown Additional Populations and/or Habitat  
**DR** -- Delisted Taxon, Taxonomic Revision (Improved Understanding)  
**AD** -- Proposed Delisting  
**AE** -- Proposed Reclassification to Endangered  
**AT** -- Proposed Reclassification to Threatened

***Appendix G – Environmental Monitoring and Protection  
Plan***

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# **Sea Launch Environmental Monitoring and Protection Plan**

**30 August 1999**  
**Revision No. 1**

Prepared for:

Office of Commercial Space Transportation  
Federal Aviation Administration  
US Department of Transportation

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1. Purpose

The Sea Launch Environmental Monitoring and Protection Plan (EMPP) will direct steps to be taken by Sea Launch Company to monitor for significant impacts that could be caused by its operations, assess these monitoring data, and report the results to the government. Over time, the EMPP provides the mechanism for Sea Launch to identify and understand the risks posed by its operations, and to strive to continuously minimize resulting impacts to the environment.

2. U.S. Government Oversight

The EMPP is an integral part of the Launch License granted to Sea Launch by the US Department of Transportation Federal Aviation Administration (FAA). The FAA Launch License authorizes Sea Launch to launch commercial satellites under the jurisdiction of the United States Government. As part of the licensing process, an environmental assessment (EA) was done to determine the possible effects of the launch operation.

In the course of the EA, many actions were identified and taken where feasible to eliminate risks and mitigate impacts due to Sea Launch operations. Those actions are not addressed here. Instead, this EMPP explains how Sea Launch will assess and document the potential impacts that could not be eliminated, and if impacts are observed to occur, initiate actions to minimize or prevent those impacts in the future.

The EMPP covers all launches conducted by Sea Launch under licenses issued by FAA, and it will be reviewed as a part of ongoing FAA license monitoring efforts. It will be updated when changes to Sea Launch operations introduce new risks to the environment, or when prior reasons for concern are eliminated. This version of the EMPP is the first revision to the original, 8 March 1999, EMPP.

FAA may also determine that the EMPP overlooks areas of study needed to adequately understand environmental risks and impacts posed by Sea Launch operations. In this case, changes to the EMPP will be incorporated as a routine part of the FAA licensing process.

The overall objectives of the EMPP are to:

- Cause significant resources that may be jeopardized to be noted, and prompt actions necessary to protect those resources during a launch;
- Document and assess significant impacts to the atmosphere and ocean surface that might occur during a launch; and
- Provide a framework for improving operational procedures and equipment in order to maximize safety.

Under provisions of the launch license process, FAA must approve the EMPP, and Sea Launch is responsible for providing EMPP-generated data to the FAA. The FAA has final responsibility for analyzing the data and initiating any necessary reviews of or changes to Sea Launch operating procedures and equipment based on these data.

### 3. Monitoring and Protection Approach and Plan

Environmental monitoring is normally done in geographical areas that are at risk of being critically altered or damaged as a result of a human activity. If monitoring is properly planned and carried out, the resulting data will serve to validate, update or challenge assumptions and design decisions made during the activity's planning and government approval process.

In this manner, the nature of Sea Launch operations and the environment was considered in formulating the EMPP to detect and assess possible impacts from Sea Launch operations at sea. The resulting plan prescribes monitoring immediately prior to and after each launch in the general vicinity of the launch location. More specifically, the timeframe of greatest interest is during rocket propellant loading, ignition and initial flight. This encompasses the area and time of greatest risk from potential accidents during operations and from the sound and heat released during a launch. This is shown on figures in the appendix for the first launch location at 154° longitude on the equator, southeast of Kiritimati, Republic of Kiribati.

Given the scale of the environment relative to the Sea Launch operation, the EMPP for the first launch is designed to detect the most likely evidence of potential impacts that might be there, and to do this as effectively as possible. This factor led to the identification of four elements (see box), which collectively focus on the greatest risks of impact from operations. As the EMPP is implemented during the first and subsequent launches, data will allow consideration of revisions to the EMPP to address positive indications of risk and impact, or to refocus monitoring efforts in more productive ways.

Following this approach, therefore, four independent EMPP elements are planned.

Element	Specific objective
Wildlife detection and impact determination	Document and minimize risk to wildlife
Atmosphere disruption and recovery analysis	Record physical effects on atmosphere due to rocket ascent
Surface water sampling and impact detection	Assess extent of kerosene release
Notices to local mariners	Ensure adequate notice is given before launch

The first three elements focus on environmental resources, while the fourth concerns public safety. EMPP monitoring (Elements 1, 2 and 3) begins after the Launch Platform reaches ballasted position, i.e., is semi-submerged for launch, and ends after a successful launch or securing following an abort decision. The baseline plan assumes a successful launch, but allows for possible impacts that might occur during a failed launch. Each element is reviewed in general below and in detail in the appendix.

### 3.1 Visual observations for species of concern at launch location

Presence or absence of wildlife in the general vicinity of the Launch Platform (LP) will be documented based on visual observations made during daylight hours from the bridges of the Assembly and Command Ship (ACS) and the LP (when manned). Species of general interest are mammals (pinnipeds and cetaceans), sea birds, reptiles (turtles), and fish of commercial interest, while those that are considered to be endangered or threatened are of particular importance (appendix I.3). Training and/or the review of self-instruction materials on the identification of species of concern is held before arrival at the launch site. Sea Launch is presently exploring the possibility of contracting with a Kiribati-based organization to produce additional training materials to help identify species of concern.

Although the area within visual range in all directions will be surveyed and documented, the area within 100 meters or so of the LP stern is of particular concern (appendix I.2). Observations will be logged onto a standard form (appendix I.4) and compiled after the launch mission for analysis and reporting to FAA. Sea Launch is presently exploring the possibility of mounting fixed closed-circuit cameras to monitor the 100 meter area better. Options include mounting the cameras on the LP as well as deploying buoys with mounted cameras. If this approach is found to be feasible and cost-effective, it will be employed at a later date.

### 3.2 Remote detection of atmospheric effects during ascent

The ACS is outfitted with state-of-the-art weather radar equipment for monitoring atmospheric processes to ensure safe weather conditions prior to a launch. This resource will be used to capture available data on the ascent plume trace to record, to the extent detectable, the disruption and rate of recovery of the atmosphere during ascent (appendix II.2). Basic equipment specifications are provided (appendix II.3) to acquaint potential users of equipment and data parameters. Optical tracking video recordings of the launch will also be archived to augment the study of radar digital data.

This equipment has never been applied to the study of exhaust plumes. As such, it is unclear to what extent the captured radar digital and video data resolutions will support the objectives of characterizing rocket exhaust plume effects. Sea Launch will, however, utilize its capabilities to attempt to detect and measure the ascent plume. Collected data will be archived and made available through FAA for basic research in this area.

### 3.3 Surface water sampling to detect possible launch effects

Surface water samples will be collected by hand from a small craft in open waters and in a down-current direction from the Launch Platform (appendix III.2). The ‘background’ samples will provide baseline data on the ocean surface water, and the ‘down-current’ samples will indicate the presence or absence of kerosene pollutants that could conceivably be lost to the ocean during rocket propellant loading and launch.

As soon as safely possible after the launch nine samples will be taken in a rectangular grid downstream of the LP. The down current samples will be collected after calculating the current drift and wind conditions at launch time so as to ensure the water sampled represents the maximum exposure to contaminants. Samples will only be analyzed for Kerosene hydrocarbons, i.e., of all materials and operations onboard the Launch Platform, only a release of Kerosene would be a concern. It should be noted, however, that tests confirm propellant loading equipment performs without leaking, and that these tests are planned for each launch.

Sea Launch is presently exploring the possibility of deploying automatic sampling devices attached to buoys which can be trailed in the water during launch time. If this approach is found to be feasible and cost-effective, it will be employed at a later date as a substitute for the hand sampling method.

Sample collection, handling, labeling, preservation, chain-of-custody, and analysis methods follow accepted scientific standards and are provided in appendix III. Evidence of pollution from launch operations will prompt Sea Launch to study the cause of Kerosene loss, its possible impact, and corrective measures.

### 3.4 Notices to Local Mariners

Notices to mariners are routinely broadcast prior to launches from the United States to vessels with an INMARSAT-C transceiver or HF band receiver. As this coverage is not guaranteed to reach mariners in the vicinity and east of 154° longitude on the equator, notices will be augmented with an additional, standard message (appendix IV.2) to affected parties. Distribution and posting of this message, in hard copy by fax, will be coordinated with Kiribati government and regional authorities and sport boat and fishing fleet operators (appendix IV.3 and IV.4). Messages will contain an internet address for interested parties to check for up-to-date information about each launch.

## 4. Plan Implementation Guidelines

At all times in the performance of the EMPP, safety of personnel is the first priority. In this regard, tasks required for Elements 2 and 3 shall be approved as part of routine Operations scheduling with regard to safety. Any condition, e.g., sea state, weather,

visibility, or conflicting activities, that potentially creates an unsafe situation for EMPP personnel, is justification for modifying, delaying, or canceling the EMPP activity. If this occurs, the EMPP team will document as part of its record the conditions and decisions that caused EMPP implementation to be interrupted.

5. Report to FAA

Sea Launch will compile, evaluate, summarize and report on the data collected during EMPP implementation. The report to FAA will provide a brief description of the implementation activity - particularly as it deviates from the plan. The report will also include data summaries, the approaches used in evaluating the data and the basis for conclusions where appropriate, and the raw data in appendices. Following FAA review, EMPP results will be made available to the public; accordingly, the report submitted to FAA by Sea Launch will be suitable for the general public in terms of completeness, format and style of writing.

## Appendix I.1

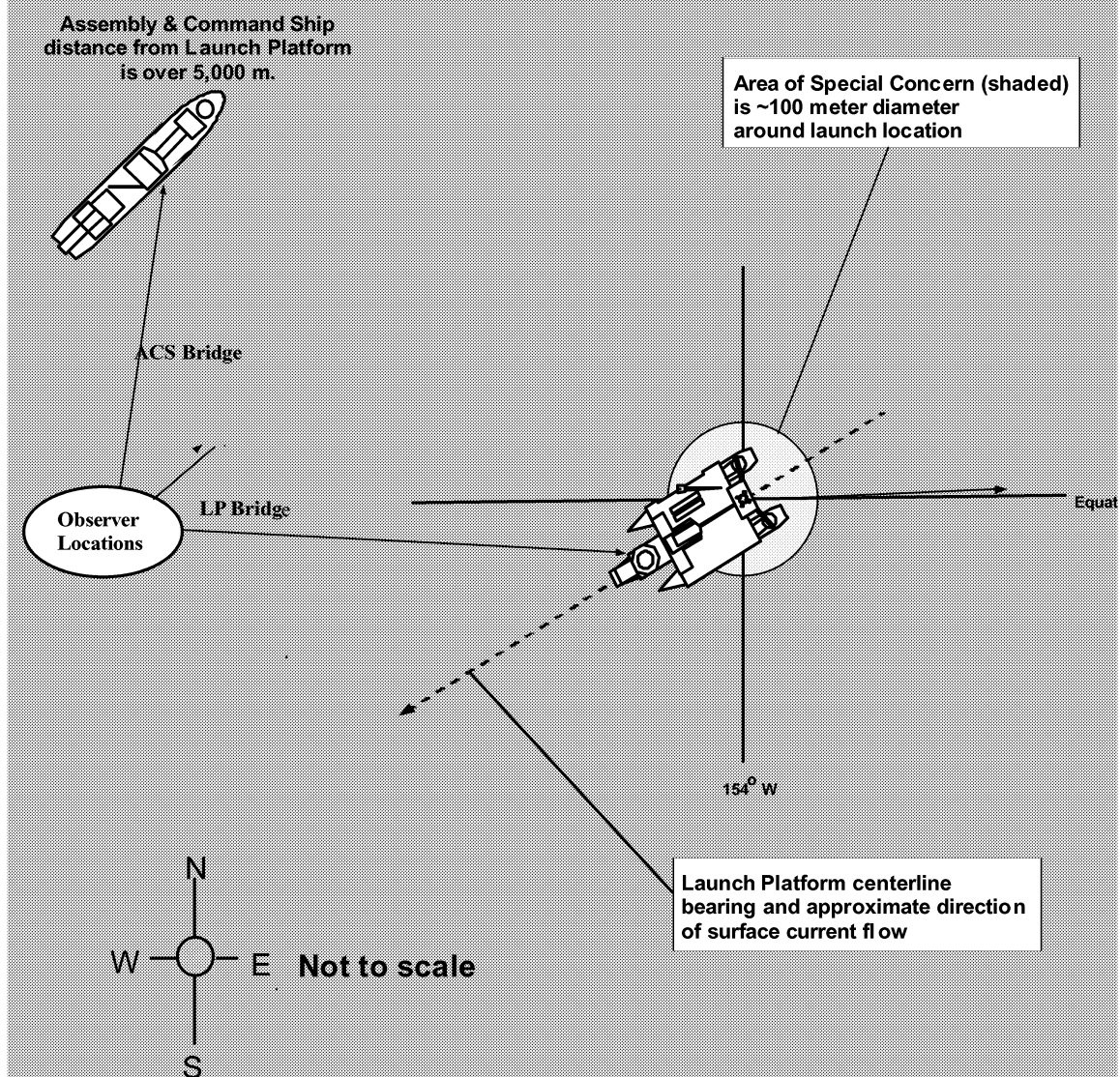
### Protocol - Visual observation for species of concern at launch location

The following outlines study parameters. See appendix I.5 for operations procedure.

Duration and area of study:	While LP is in semi-submerged position. Visual distance from bridges of ACS and LP (when manned). Area of special concern is within 100 meters or so of LP (appendix I.2).
Observer and location:	Duty Officers on ACS and LP bridges.
Regimen:	Continuous observation during daylight hours, with notations made at least hourly of wildlife sightings or the lack of sightings.
Record keeping:	Notations made by Bridge officers (appendix I.4).
Wildlife taxonomy (species of special concern listed in appendix I.3); more generally:	<ul style="list-style-type: none"><li>• Mammals (Cetaceans, Pinnipeds)</li><li>• Sea turtles</li><li>• Sea birds</li><li>• Commercial fish</li></ul>
Record as can be determined (field guides and basic training provided to observers):	<ul style="list-style-type: none"><li>• Type and number of individuals observed</li><li>• Specie, sex and age of individuals</li><li>• Proximity to and duration in observation area</li><li>• Behavior, bearing, speed</li><li>• Behavior possibly caused by operations</li></ul>
Records and reporting:	Observers will retain Record sheets for collection by the Safety/Security Coordinator. The Director, Safety and Mission Assurance, will compile and analyze the record for incorporation in the report submitted to FAA.

Appendix I.2

**Figure 1 Plan for Visual Observations for Species of Concern**



### Appendix I.3

#### Species of Concern<sup>1</sup>

The following species are listed as Threatened or Endangered by the United States and are known to occur in the equatorial Pacific Ocean region.

##### **Whales:**

- Endangered - Whale, blue (*Balaenoptera musculus*)
- Endangered - Whale, bowhead (*Balaena mysticetus*)
- Endangered - Whale, finback (*Balaenoptera physalus*)
- Endangered - Whale, humpback (*Megaptera novaeangliae*)
- Endangered - Whale, right (*Balaena glacialis* (incl. *Australis*))
- Endangered - Whale, Sei (*Balaenoptera borealis*)
- Endangered - Whale, sperm (*Physeter macrocephalus* (=catodon))

##### **Birds:**

- Endangered - Petrel, Hawaiian dark-rumped (*Pterodroma phaeopygia sandwichensis*)
- Threatened - Shearwater, Newell's Townsend's (formerly Manx) (=a'o) (*Puffinus auricularis newelli*)

##### **Sea Turtles:**

- Endangered - Turtle, green sea (*Chelonia mydas*) (East coast Florida and West coast Mexico only)
- Threatened - Turtle, green sea (*Chelonia mydas*)
- Endangered - Turtle, hawksbill sea (*Eretmochelys imbricata*)
- Endangered - Kemp's (=Atlantic) ridley sea (*Lepidochelys kempii*)
- Endangered - Turtle, leatherback sea (*Dermochelys coriacea*)
- Endangered - Turtle, loggerhead sea (*Caretta caretta*)
- Threatened - Turtle, olive (=Pacific) ridley sea (*Lepidochelys olivacea*)

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<sup>1</sup> U.S. Listed Vertebrate Animal Species <http://www.fws.gov/r9endspp/vertata.html>

<b>Date (d/m/y):</b> _____ <b>Observer:</b> _____ <b>Observer location</b> <b>(circle one):</b> <b>ACS</b> <b>LP</b> <b>Weather/Sea Conditions:</b> _____	<b>Key for Record Entries</b> <b>General Type:</b> <u>M</u> ammal, <u>R</u> eptile, <u>S</u> eabird, <u>F</u> ish <b>Location:</b> Bearing/distance from LP <b>Ex. of behavior:</b> Direction and speed of travel Breaching frequency Grouping and pairing Interaction between individuals Response to SL operations
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[illegible]

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## Appendix I.5

### Operations Procedure for Wildlife Observations

#### Background

1. Monitoring is to be performed during daylight hours while the Launch Platform is in the semi-submerged launch position.
2. Area to be surveyed is that observable by eye in all directions; binoculars are to be used when necessary to confirm sightings or determine species, etc.

#### Monitoring by Duty Officers on LP bridge and ACS bridge

Standard practice: Each hour on the hour, observers stationed on the bridge of each vessel are to survey the water surface and sky, and record the presence or absence of wildlife observed in as much detail as possible.

Exception: Any time any wildlife is observed, the observer is to record its presence in as much detail as possible.

#### Custody of records

The observers on the LP bridge and ACS bridge are to keep their complete records of observations in secure locations on each bridge as part of the ship's log during the monitoring period until turned over to the Safety/Security Coordinator following the monitoring period.

Upon return to Home Port, the Safety/Security Coordinator will provide the records to the Director, Safety and Mission Assurance, for assignment to staff for the purpose of analysis and incorporation into an EMPP report for FAA.

## Appendix II.1

### Protocol - Remote detection of atmospheric effects during ascent

The following outlines study parameters and operations procedure.

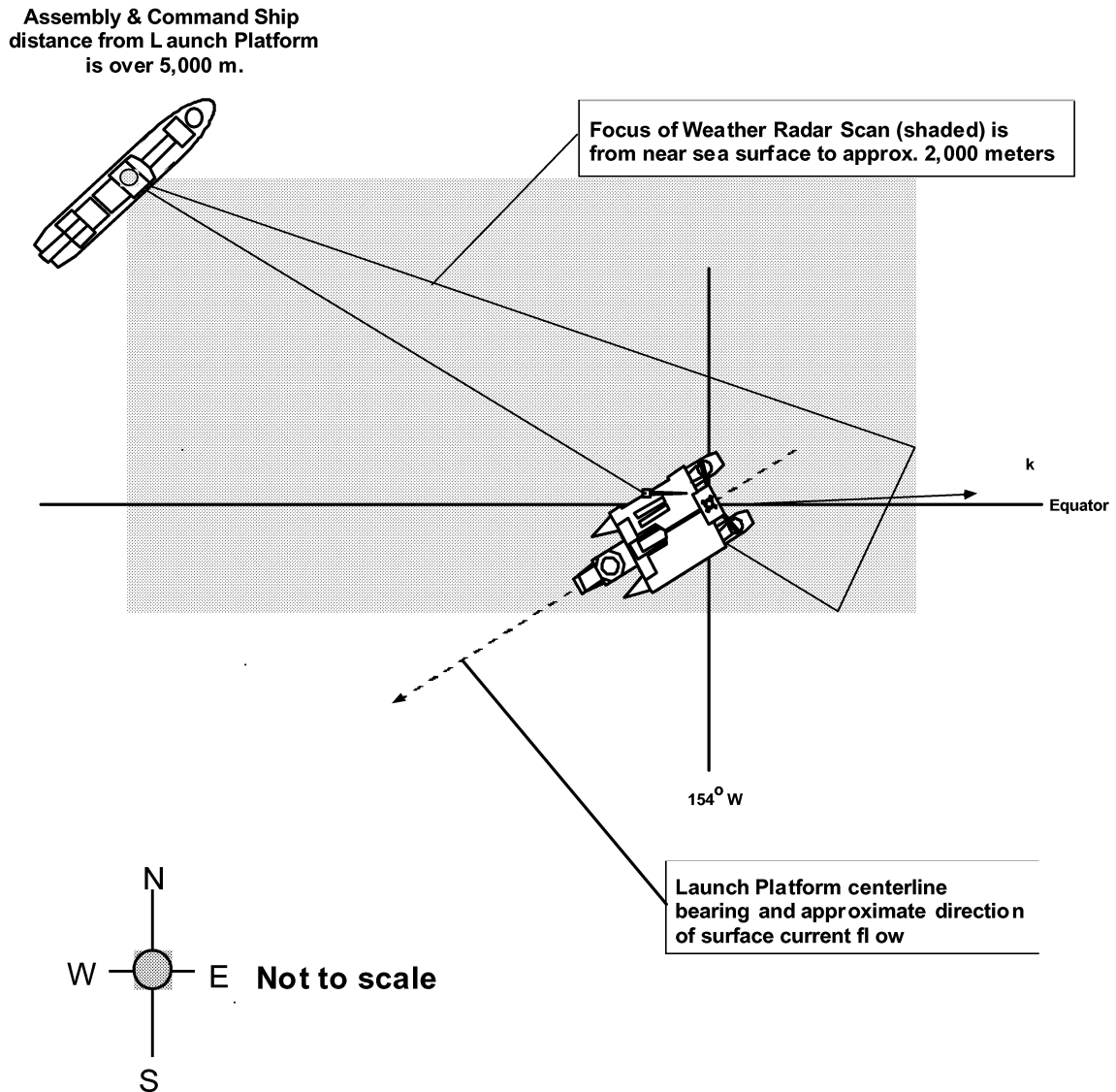
Area of study:	Ascent plume trace as scanned by radar equipment and recorded by video equipment (appendix II.2).
Method:	Activities will be scheduled as a part of operations. <ol style="list-style-type: none"><li>1. Pre-programmed weather radar scan by ship Meteorologist bracketing launch.</li><li>2. Optical tracking video of launch ascent</li></ol>
Radar scan duration:	L-30 through L-15 minutes (background) L+0 through L+ 15 minutes (ascent trace)
Record keeping:	<ol style="list-style-type: none"><li>1. Digital files generated by radar system</li><li>2. Optical tracking video copy</li></ol>
Data analysis:	Radar and video data will be used to determine - to the extent possible - the magnitude and duration of the ascent plume. The data will be examined against the weather radar equation relating received power to range and cloud reflectivity. Analysis will involve graphing the signal level verses altitude in order to characterize particulate presence <sup>2</sup> .
Reporting:	The Safety/Security Coordinator will retain stored data and video copies following launch operations. Upon return to Home Port, the Safety/Security Coordinator will provide the records to the Director, Safety and Mission Assurance, for assignment to the Mission Operations meteorologist for the purpose of analysis and incorporation into an EMPP report for FAA.

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<sup>2</sup> *The Use of Aviation Weather Radars for In Situ Measurements of Contrail Cirrus*, Tank and Thomas, Boeing Co. Seattle Washington, 33rd Aerospace Sciences Conference January 9-12, 1995. Reno, Nevada, AIAA publication 95-0542.

Appendix II.2

**Figure 2 Plan for Remote Detection of Plume Effects**



## Appendix II.3

### Sea Launch Command Ship Weather Radar System

#### **Introduction**

The Sea Launch command ship represents a unique source of meteorological data that are collected and archived during the periods it is on location for a launch. In general, the ship will be operating a C-Band Doppler Weather Radar using a stabilized antenna, an ocean Wave Radar, and an upper air rawinsonde balloon soundings in support of launch operations.

As part of the EMPP, meteorological data from the Weather Radar will be used to document the physical response in the atmosphere following the ascent of the rocket. It is expected that there are limits in the level of resolution available from the equipment, however, analysis of these data may further the launch industry's basic understanding of atmospheric physical processes during a launch, and help gauge the effect of the Sea launch rocket on the atmosphere.

The archived records, coupled with video recordings, also represent a potentially important data set to researchers interested in the meteorology of an oceanic equatorial location. Accordingly, the raw meteorological data generated by Sea Launch Company will be made available to support these basic research interests. With that in mind, the following general descriptions of the Sea Launch meteorological equipment are provided for consideration by researchers interested in using archived data.

#### **The C-Band Doppler Weather Radar System Specifications**

The mission of the weather radar systems is to scan the area around the launch site out to a distance of about 320 km (170 nmi). The weather radar provides continuous, alarmed, threshold assessment of critical launch commit criteria such as lightning potential, rain, storm, and freezing level, and cloud threat extrapolation.

The system utilizes a commercial radar system (i.e., Kavouras 3070-C radar). This consists of a 3 meter offset feed pencil beam antenna, 7.5kW peak power fully coherent Travelling Wave Tube (TWT) transmitter, receiver, and signal processor. This is integrated with a Sigmet RCP-02 antenna controller, a Seapath 200 INU system, and two HP workstations. Key component specifications are listed in Tables II.1 and II.2.

**Table II.1 Transmitter/Receiver Subsystem Specifications**

Peak Power	7500 watts
Max Average Power	135 watts
Pulse Width	2.5 $\mu$ s, 5 $\mu$ s, 10 $\mu$ s or 20 $\mu$ s
Dynamic Range	105 dB
PRF	200 to 3000 Hz

**Table II.2 Antenna Parameters**

Beam Width	1.3 degrees
Gain	42 Db
Side Lobes	-35 dBc (typical)
Azimuth Speed	0 to 6 RPM
Elevation Speed	0 to 6 RPM

## **Wave Radar**

The wave radar system (MIROS brand) is an advanced microwave sensor specially designed for real time measurements of directional ocean wave spectra and surface current. The wave radar sensor outputs processed directional wave-spectra over a digital serial interface or network. The wave radar is operated and maintained as part of the marine segment on the ACS. The wave data is collected and analyzed by the loads measurement system and passed on to the weather measurement and reporting system for further analysis and forecasting. The main functions of the wave radar are to:

- Collect sea surface information from the back-scattered radar signal
- Process the back-scattered signals into wave and current time-series
- Perform power spectrum analysis
- Estimate surface current components
- Calculate wave spectrum parameters
- Calculate integrated wave parameters (significant wave-height, wave period, wave direction, etc.)
- Estimate surface current vector (current speed and direction)
- Perform real-time data quality control
- Generate and transmit data on a serial output format (MIROS DF-005/WR)

The wave radar uses active microwave remote sensing techniques to collect sea state data, i.e., surface wave and current information from the ocean surface. The radar is designed to operate unattended. When the main power is turned on, the system software is automatically transferred from the hard disk into the working memory. The software initializes the sensor hardware and starts data collection. Each of the six horns of the

antenna array covers a 30 degrees sector. Raw data are collected as 128 second time-series (256 samples) in each direction. During a complete directional scan, data are collected from all six directions covering 180 degrees included angle. One complete scan takes about 15-16 minutes, dependent on the speed of the CPU. Note that although data are available on the serial data output every minute, the wave and current estimates are updated only after each scan. Table II.3 shows the wave radar performance specifications:

**Table II.3 MIROS Wave Radar Performance Specifications**

Waves	Height	0.2-20 m +/-5 %
	Period	3-30 s +/-5%
	Direction	0 to 360 deg +/- 7 deg
Current	Speed	0 to 2.5 m/s +/- cm/s
	Direction	0 to 360 +/- 7 deg
Wave Directional Spectra	Frequency Resolution	0.078125 Hz
	Frequency Range	0.3125 Hz
	Directional Resolution	30 deg (nominal)
	Directional Range	0 to 360 deg (unambiguous)

### **Rawinsonde Balloon System**

Upper air conditions are critical to launch vehicle loads and controllability. Commit criteria have been established for wind speed and direction and wind shear. Upper air conditions are measured at least five times during the L-48 hour countdown leading to launch and once after launch for post-launch analysis. These same upper air soundings would be useful in verifying global prediction models as a source of “truth” data for the oceanic equatorial region where presently such data exists. Sea Launch will provide a backup processor for analyzing data collected from the balloon system on the ACS. Key specifications are listed in Table II.4.

**Table II.4 Rawinsonde Component Specifications**

Parameter	Range	Accuracy
Pressure	1060 to 3 hPa	0.1 hPa
Temperature	+60 to -90 C	0.1 C
Humidity	0 to 100% RH	1% RH
Wind Speed	0 to 180 m/s	0.1m/s
Wind Direction	0 to 360 deg	1 deg

Wind Vector Accuracy	--	0.5-0.2 m/s (GPS)
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### Appendix III.1

#### Protocol - Surface water sampling to detect possible launch effects

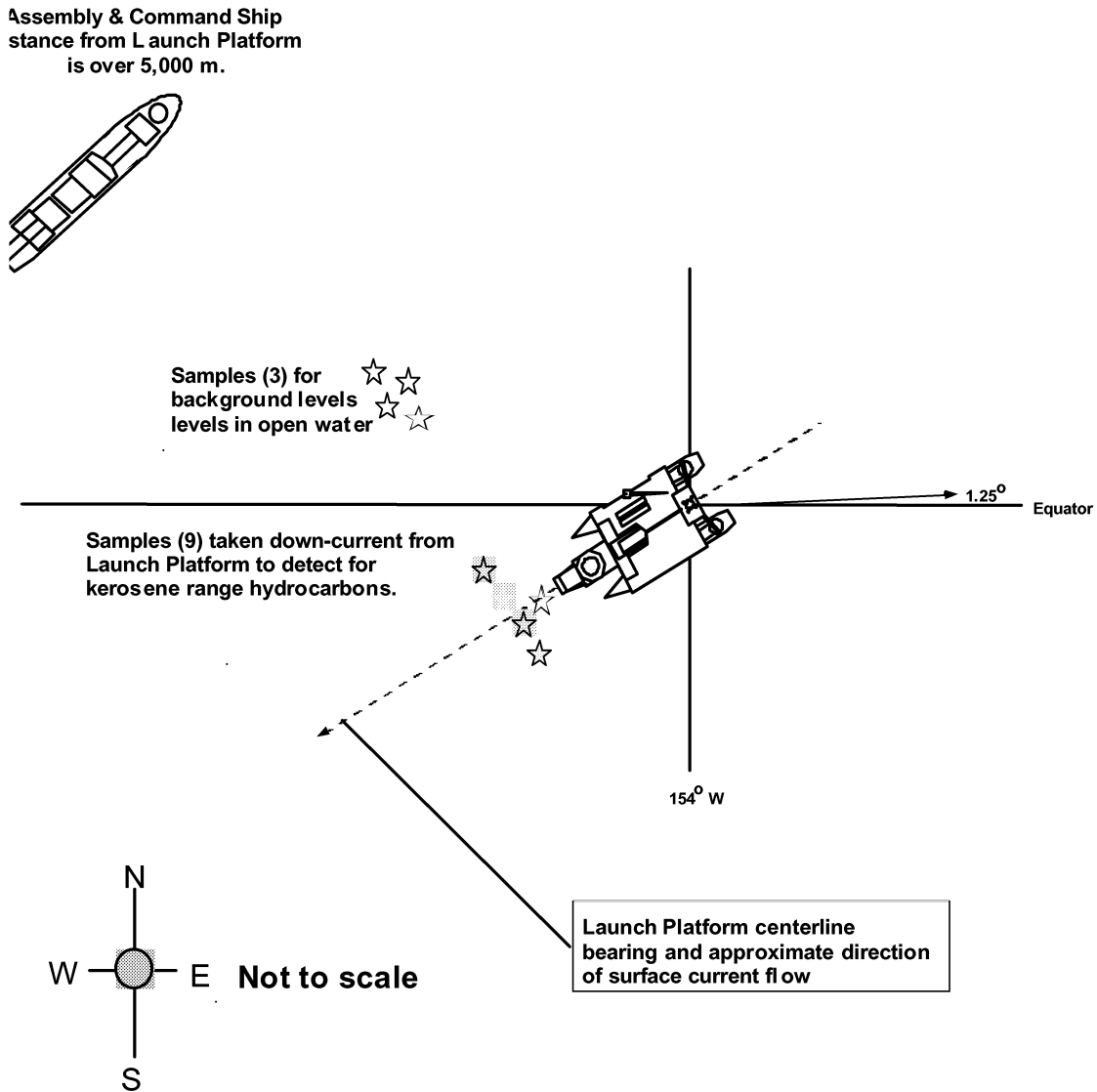
The following outlines study parameters. See appendix III.3 for procedure.

Area of study:	Sampling stations positioned relative to Launch Platform (appendix III.2).
Method:	Discrete sampling of surface waters in prepared glass bottles by hand from small craft as LP is re-entered; three background samples and nine down-current samples; exact times to be determined and recorded by Operations team, after considering personnel safety and calculating the current set and drift at the time of launch. The three background samples are to be collected at an up-current location from the LP The nine down-current samples are to be collected in a rectangular grid . Each sample should be collected from a location at least 20 meters from the others.
Sample preservation:	One litre glass bottles, with small airspace, capped and held under custody control in a ship refrigerator.
Analysis parameters:	EPA Method 8015B, Nonhalogenated Organics using Gas Chromatograph/Flame Ionization Detector
Data analysis:	Results of EPA method 8015B to be evaluated and reported by the analytical laboratory, and evaluated and summarized in report to FAA by Director, Safety and Mission Assurance staff.
Supplies:	12 - 1 liter bottles, pre-labeled screw caps with TFE-fluorocarbon liners labels, tape, and marker pens cooler container for bottles/supplies sampling record and custody form

- Sample, record, and data custody:    The following custody sequence will be maintained
- Sample bottles in cooler maintained by Safety/Security Coordinator
  - Sea Launch Safety/Security Coordinator during sampling and when stored at-sea
  - Director, Safety and Mission Assurance when at Home Port
  - Contract laboratory during analysis
  - Director, Safety and Mission Assurance to retain laboratory results and incorporate results in report to FAA

Appendix III.2

**Figure 3 Plan for Surface Water Sampling**



Appendix

<b>Sea Launch Environmental Monitoring and Protection Plan Sampling Record</b>
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**Weather/Sea Conditions:**

**Directions for taking and maintaining surface water samples:**

1. Jars, lids, liners and labels are prepared in advance; coordinate with to take 3 samples away from ACS and LP and 9 samples down-
2. Gradually submerged jar, allowing surface water layer to flow into contamination from small craft boat
3. Leave small airspace in jar; secure lid; return jar
4. After return to ACS, apply tape seal to cooler lid and sign for
5. Place in refrigerator; guard against
6. At Home Port, transfer custody to Director, Safety and Mission

<b>Background Samples</b>	<b>SAMPLE CUSTODY ON</b>				
<b>Date taken:</b> _____ <b>Time taken</b> _____  <b>Location:</b> _____	Transferred from sample _____  <b>Transfer date:</b> _____  <b>Transfer time (UTC):</b> _____  <b>Stored on ACS in galley fridge</b>  <b>Fridge unit temp.:</b> _____				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; text-align: center;"><b>Sample Numbers</b></td> <td style="text-align: center;"><b>Samples labeled and signed?</b></td> </tr> <tr> <td style="text-align: center;">1, 2, and 3.</td> <td style="text-align: center;">Yes    No</td> </tr> </table>		<b>Sample Numbers</b>	<b>Samples labeled and signed?</b>	1, 2, and 3.	Yes    No
<b>Sample Numbers</b>		<b>Samples labeled and signed?</b>			
1, 2, and 3.		Yes    No			
<b>Down-Current Samples</b>					
<b>Date taken:</b> _____ <b>Time taken</b> _____  <b>Location:</b> _____					
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; text-align: center;"><b>Sample Numbers</b></td> <td style="text-align: center;"><b>Samples labeled and signed?</b></td> </tr> <tr> <td style="text-align: center;">4 through</td> <td style="text-align: center;">Yes    No</td> </tr> </table>	<b>Sample Numbers</b>	<b>Samples labeled and signed?</b>	4 through	Yes    No	
<b>Sample Numbers</b>	<b>Samples labeled and signed?</b>				
4 through	Yes    No				

<b>Samples Chain of Custody Record</b>			
<b>Date</b>	<b>From</b>	<b>To</b>	<b>Purpose</b>

## Appendix IV.1

### Protocol - Notices to Local Mariners

The following outlines the parameters for this activity. See appendix IV.3 for procedure.

Area of applicability: Vessels in general vicinity of 154° on equator and points east.

Methods: For vessels with INMARSAT-C transceiver:

Messages will be broadcast using US Government protocols via INMARSAT-C, POR (Pacific Ocean Region) satellite on Safety Net channel at 10:00-10:30 and 22:00-22:30 GMT each day starting 5 days prior to each launch. This standard US Government method is not expected to reliably alert vessels in the Christmas Island area.

The message is also broadcast on frequencies in the HF band by U.S. Coast Guard, Honolulu, however, this is not expected to reliably extend to the Christmas Island area.

For vessels without receiving equipment:

Standard message (appendix IV.2) will be delivered in hard copy by fax to points-of-contact (appendix IV.4) who will ensure distribution to:

- Christmas Island local authorities and tour boat operators for posting and distribution;
- The Ministry of Information, Communication and Transport (MICT) for posting; and
- The operators of regional fishing fleets at their headquarters, e.g., national and industry operators

Record keeping: Record of notices made will be maintained by Sea Launch and provided in the report submitted to FAA.

Appendix IV.2

Sample Notice to Local Mariners

Date March 13,  
To: Hon. Tiim Taekiti, PS David  
Ministry of Line and Phoenix  
Republic of  
**Subject Notice to Mariners of Planned Rocket**  
From Sea Launch Range  
2700 Nimitz  
Long Beach, CA  
562-951-7000, Ext. 2003 or 562-951-

This communication is to inform you of the planned launch of a rocket by Sea Launch location 240 NM Southeast of Christmas Island, Republic

**Location Launch Platform** 0° 00' N, 156° 00' W.

**Date: 26 March**

**Time: 22:14 - 02:14 (27 March) GMT**

In the interest of safety, vessels are advised to stay clear of areas bounded

0° 10' N - 0° 10' S ; 156° 20' W - 156° 20' W

0° 00' N - 0° 20' N ; 156° 01' W - 156° 29' W

0° 03' S - 0° 30' N ; 156° 57' W - 156° 41' W

0° 27' N - 0° 77' N ; 156° 00' W - 156° 56' W

Please provide this information to vessel operators within your area of general vicinity of these four

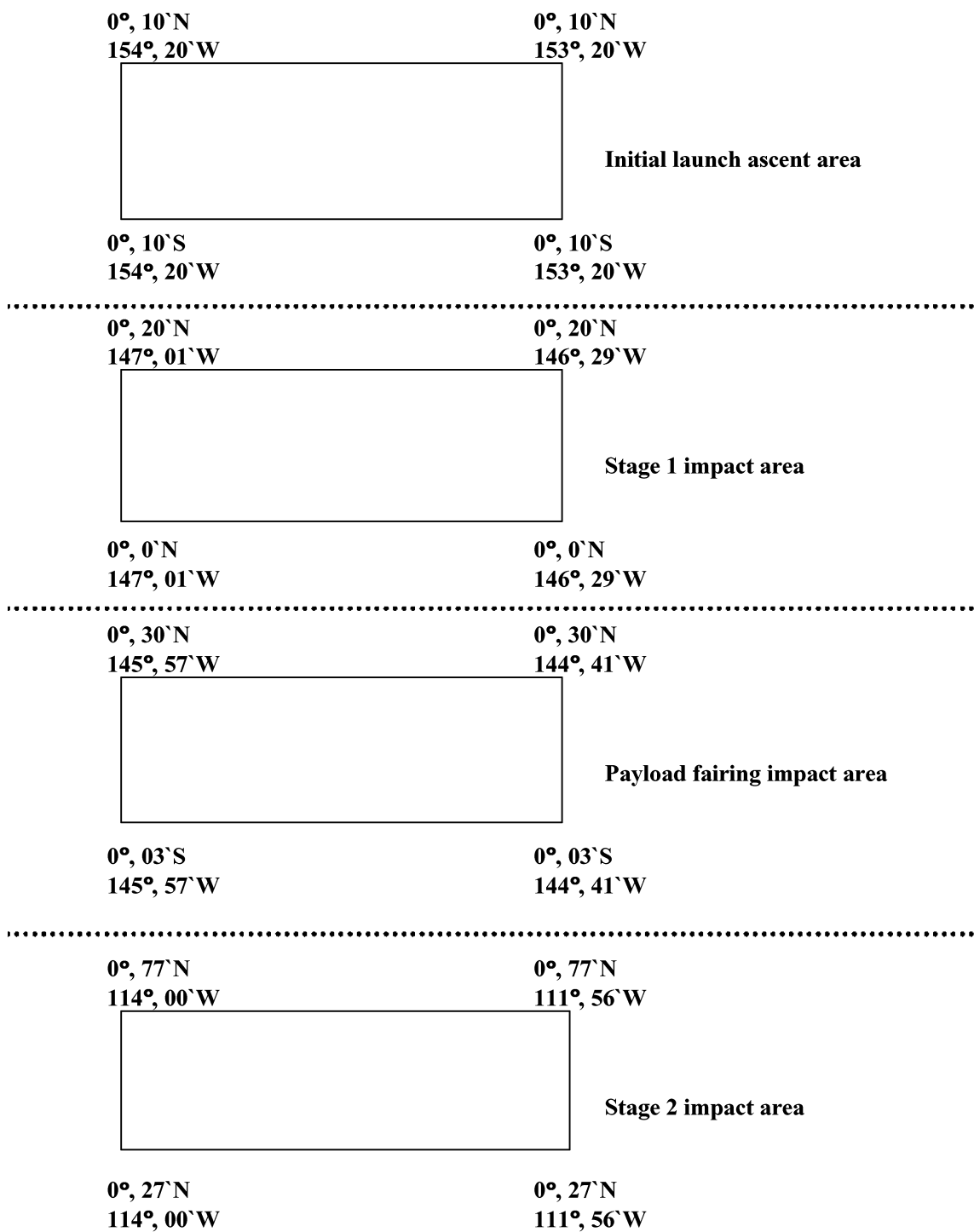
Please contact Sea Launch **562-951-7000** or **562-951-** if you have any

Thank you,

Rick  
**Range**  
Sea Launch  
Boeing Commercial Space

## Appendix IV.2

### Sample Notice to Local Mariners (continued)



### Appendix IV.3

#### Operations Procedure for Notices to Local Mariners

##### Background

Prior notice of a launch is to be distributed by facsimile to the organizations listed in Appendix IV.4. Each organization, in turn, is responsible for communicating the same or similar notice to their community or members by any means they choose. The notice is to be provided to each organization several weeks prior to a planned launch.

##### Notice Distribution

The list for notice distribution is provided on Appendix IV.4, which is formatted to serve as the Sea Launch record of notices made prior to a launch. The Range Coordinator will ensure broadcast of the notice to organizations on this list. Notice receipt is considered confirmed by a prior phone call made to the office to confirm the accuracy of the facsimile number to be used, and by the record of successful facsimile transmission.

## Appendix IV.4

### Record of Notice Distribution

Mission Name:

Scheduled launch date:

<b>Organization to be notified</b>	<b>Fax number; date number confirmed</b>	<b>Notifications Made (date and initials)</b>
Hon. Willie Tokataake, PS Taakei Taoaba Ministry of Information, Communications and Transport Republic of Kiribati	Ph. 686-26003 or 26435 Fx 686-26193 5 Mar 99	
Hon. Tiim Taekiti, PS David Yeeting Ministry of Line and Phoenix Development Republic of Kiribati	Ph 686-81212 Fx 686-81278 5 Mar 99	
South Pacific Regional Envir. Programme C/O Mr. Tamari'i Tutangata, Director PO Box 240 Apia, Western Samoa	Ph. 685-21929 Fx 685-20231 2 Mar 99	
South Pacific Forum Fisheries Agency C/O Ms. N. Barbara Hanchard, Director PO Box 629 Honiara, Solomon Islands	Ph 677-22214 Fx 677-23995 2 Mar 99	
United States Tuna Foundation C/O Mr. David Burney One Tuna Lane San Diego, VA 92101	Ph 619-233-6407 Fx 619-233-8336 2 Mar 99	
Inter-American Tropical Tuna Commission C/O Dr. Jim Joseph, Director 8604 LaJolla Shores Drive LaJolla, CA 92037	Ph 619-546-7100 Fx 619-546-7133 2 Mar 99	
Mr. Shingo Ota, First Secretary Office of the Fisheries Attache Ministry of Agriculture, Forestry and Fisheries Embassy of Japan 2520 Massachusetts Avenue, N.W. Washington, D.C. 20008	Ph 202-238-6727 Fx 202-265-9473 2 Mar 99	
Mr. Jung You, First Secretary Ministry of Fisheries Embassy of Korea 2450 Massachusetts Avenue, N.W. Washington, D.C. 20008	Ph 202-939-5676 Fx 202-387-0402 2 Mar 99	
Dr. Jack Chen, Exec. Assistant to the Director Economic Division Taipei Economic and Cultural Office in the US 4201 Wisconsin Avenue, N.W. Washington, D.C. 20016	Ph 202-686-6400 Fx 202-363-6294 2 Mar 99	